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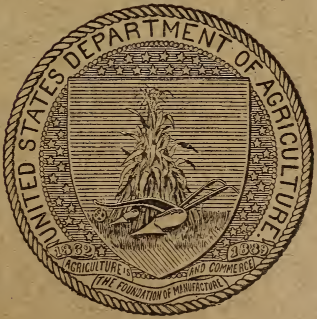
U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 148.
A. C. TRUE, Director.

REPORT

ON

IRRIGATION INVESTIGATIONS IN HUMID SECTIONS OF THE UNITED STATES IN 1903.

UNDER THE DIRECTION OF
ELWOOD MEAD,
Chief of Irrigation Investigations.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

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[Continued on third page of cover.]

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OFFICE OF EXPERIMENT STATIONS

A. C. TRUE, Ph. D., *Director.*
E. W. ALLEN, Ph. D., *Assistant Director.*

IRRIGATION INVESTIGATIONS.

ELWOOD MEAD, *Chief.*
R. P. TEELE, *Editorial Assistant.*
C. E. TAIT, *Assistant, in Charge of Central District.*
SAMUEL FORTIER, *Irrigation Engineer, in Charge of Pacific District.*
C. G. ELLIOTT, *Engineer, in Charge of Drainage Investigations.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., June 8, 1904.

Sir: I have the honor to transmit herewith a report on irrigation investigations in humid sections of the United States in 1903, made under the direction of Prof. Elwood Mead, chief of irrigation investigations, of this Office. Its publication as a Bulletin of this Office is recommended.

Respectfully,
A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., June 8, 1904.

Sir: I have the honor to submit herewith a report on investigations and experiments in irrigation in different parts of the humid region of the United States carried on by this Office in 1903. The report deals almost exclusively with the irrigation of market-garden crops. Most of these grow rapidly and have but a short season, and a few days of dry weather seriously check their growth. There are few seasons when such dry periods do not occur, and irrigation as an insurance against them has proved very profitable. In some sections this is becoming so well known that many inquiries are received as to equipment and methods of irrigating. The report of Professor Voorhees describes a number of plants now in use, and will be useful in answering such inquiries.

In sections farther west there is doubt as to the value of irrigation and some prejudice against it, and the experiments at Columbia, Mo., reported by Professor Waters, have been made for the purpose of testing the value of irrigation in that section. As may be seen from the report, irrigation has generally proved profitable.

The report of Professor Crane on the artesian basin of South Dakota shows that there have been large preparations for irrigation, but that the use of too much water has swamped the land and has in this way created a prejudice against irrigation in general and especially against the use of artesian water. However, irrigation is still practiced by market gardeners with good results, and experience has shown that there is no danger in the proper use of the artesian water. It is the use of too much water, rather than the quality of the water, which has done the damage.

The great success of irrigation of market gardens and the increased demands for agricultural products are leading to the adoption of irrigation for field crops in the humid sections of our country. In this the farmers of America are repeating the experience of farmers of Europe, who have found that there are few sections where irrigation will not pay simply as an insurance against drought. The irrigated portions of France, Switzerland, and Italy have a greater rainfall than the Mississippi Valley. The average rainfall for eighty years of the largest irrigated district in Europe is 40 inches, and is better distributed than the rainfall of Ohio, Illinois, or Iowa.

There is every reason to believe that as population increases and land becomes more valuable the zone in which irrigation can be profitably employed will be extended in this country as it has been in Europe. With higher-priced crops and more intensive cultivation irrigation will inevitably take its place as an important agency in the agriculture and horticulture of the eastern half of the United States.

Respectfully submitted.

Elwood Mead,
Chief of Irrigation Investigations.

A. C. True, *Director.*

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REPORT ON IRRIGATION INVESTIGATIONS IN HUMID SECTIONS OF THE UNITED STATES IN 1903.

IRRIGATION IN MARKET-GARDEN DISTRICTS IN THE VICINITY OF EASTERN CITIES.

By Edward B. Voorhees,
Director of the New Jersey Agricultural Experiment Stations.

During the summer of 1903 market gardens in the vicinities of New York and Boston were visited for the purpose of ascertaining the approximate cost of irrigation for such gardens and the profits due to the use of water. It was not the intention to gather statistics showing the extent of irrigation, but rather to secure the facts relating to typical systems. There are many other plants besides those described, but they are not peculiar in any particular, and their descriptions would not add to the value of this report.

TYPICAL IRRIGATION SYSTEMS.

W. F. TABER & SON, POUGHKEEPSIE, N. Y.

This plant has been in successful operation for several years and is used chiefly for the irrigation of berries, the area ranging from 4 to 6 acres. Mr. Taber is enthusiastic over the advantages of irrigation. It guarantees, first, a perfect stand and rapid growth of newly set plants; second, the highest quality of product; and third, maximum crops.

The equipment consists of a 14-horsepower gasoline engine, located near a small lake which provides for any possible demands for water even in the driest times; 1,000 feet of 2½-inch iron pipe, which is laid to the nearest point of the area to be irrigated; and 100 feet of 2-inch duck hose, which is attached to the main pipe. Mr. Taber uses the sprinkling method of irrigation almost exclusively. For this he uses a fire nozzle which is 18 inches long with a ¾-inch opening and 1-inch reduction. He has also perfected a form of flat nozzle to be attached to the fire nozzle without reduction, which enables him to obtain a fine spray. This gives a spray 4 inches wide. A ¼-inch opening is found to be most practicable with his water pressure and will send a spray 40 feet. He is particularly pleased with his form of irrigation, as it resembles in its effect a steady rain. Owing to the dry weather and high temperature during the season of 1903 his raspberries colored and hardened but did not sweeten. By the application of 10,000 gallons of water per acre, in a fine shower directly upon the fruit, the berries were put in first-class condition, well ripened and plumped out, and were ready for picking the next day. Following this spraying 25,000 gallons per acre was applied between the rows, these being the only applications needed during the dry season. He also irrigates immediately after applying chemical fertilizers rich in nitrogen, as it removes the danger of any injury to plants and also dissolves and distributes the plant food. In 1902 plant setting was successfully completed only because it was possible to previously irrigate.

PHILIP BACH, FLUSHING, LONG ISLAND.

Mr. Bach has 30 acres, all under irrigation and growing various kinds of garden truck, as lettuce, onions, beets, cauliflower, and celery. His plant, which he has used for seven years, includes a 5-horsepower engine and pump and a 10,000-gallon tank, which is set 25 feet above the surface of the ground. The water is carried from the tank by underground pipes. From hydrants placed at various intervals the water is discharged into a 2-inch gas pipe 50 or 60 feet long with six or seven 1-inch upright branches from 4 feet to 8 feet in height. To each upright is attached a "water witch," which throws a spray as heavy as a hard shower about 8 feet on each side. He has no method of measuring his water, but uses it whenever he judges it necessary and allows the witches to run one hour in one place. The pipe is then removed to the next area. It can be handled by three men, one taking each end of the pipe and the other the middle. The entire cost of his plant is estimated at $2,000. He estimates that the irrigation of his crops has been worth at least $5,000 to him this year, though the value naturally varies with the season.

FRED SCHUMACHER, FLUSHING, LONG ISLAND.

Mr. Schumacher irrigates from 15 to 18 acres, planted to onions, lettuce, celery, and carrots, and occasionally an additional area of cauliflower. He is satisfied that it would be profitable for cabbage, potatoes, and corn also. His equipment consists of a 2 to 3 horsepower engine and a 10,000-gallon tank. The water is obtained from a spring and pumped to the tank about 75 feet above the spring. He has also put in a windmill, which raises enough water in moderately dry weather. The water is carried from the tank in 2-inch galvanized iron pipes 100 to 200 feet apart, which are tapped every 200 feet. At these points 1-inch garden hose 20 to 100 feet long is attached and connected with a gas pipe 45 feet long fitted with "water witches"

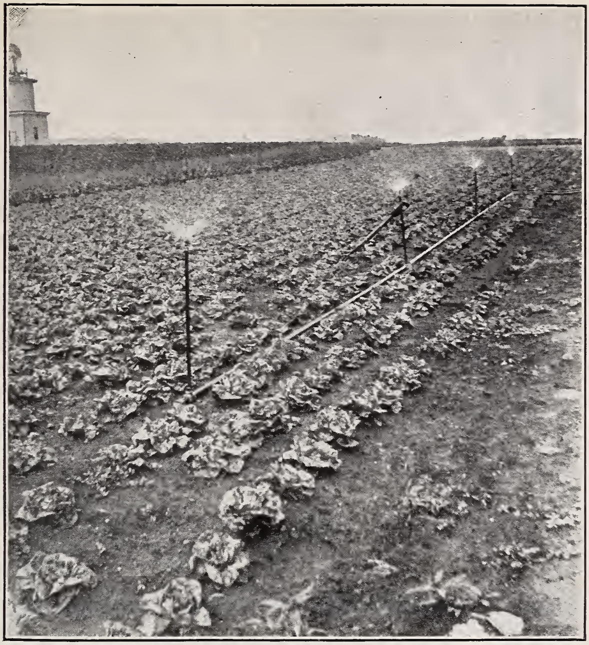

FIG. 1.—GAS PIPE AND SPRINKLERS USED BY FRED SCHUMACHER, FLUSHING, LONG ISLAND.

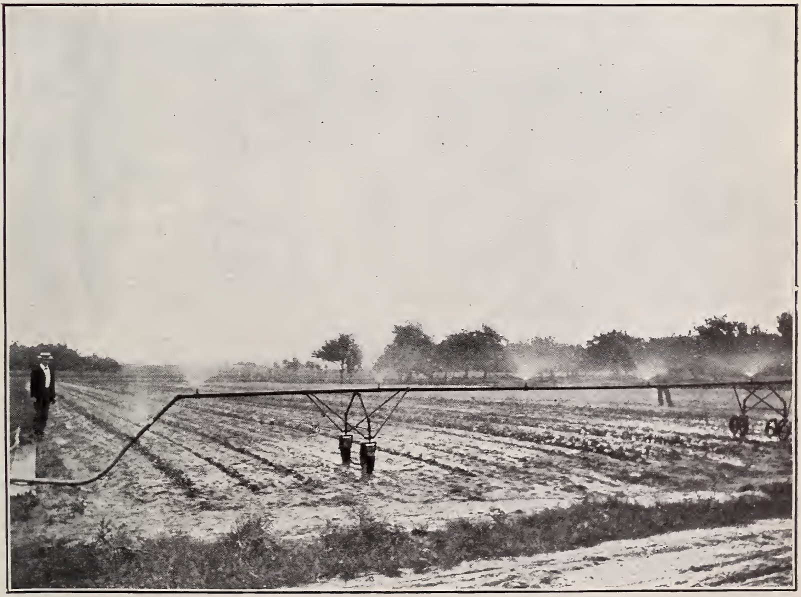

FIG. 2.—MOVABLE SPRINKLER USED BY DAVID ASTLE, VINELAND, N. J.

similar to those described above. (Pl. I, fig. 1.) It requires two men to tend the witches and one man to run the engine. He has no method of measuring the water and does not know how much he uses, but he adds water until he thinks the plants are sufficiently supplied. His plant cost about $1,500 and has been in use four or five years. He estimates his net profit from irrigation to be $500 a year.

JOHN SCHUMACHER, ELMHURST, LONG ISLAND.

Mr. Schumacher irrigates 6 to 8 acres of onions, lettuce, celery, radishes, and carrots regularly, and cauliflower and cabbage when the weather is dry. He obtains his water from the city reservoir and pays $3 per thousand cubic feet for the first thousand, $2 for the second, and $1 per thousand thereafter, and finds it is cheaper for him to purchase from the city than to provide his own pumping plant, which he formerly had, as the total cost of water used annually is only about $200. The water is carried in pipes and applied by the same method as that used by Fred Schumacher. He has irrigated for about ten years, and while he has no definite data as to the profits, he feels certain it pays, and says he would not attempt to grow market-garden crops without a guaranty of an abundance of water when needed. His experience teaches that it is necessary to water thoroughly, and he therefore soaks his soil at each application. Such plants as lettuce and celery he waters daily.

H. SCHUMACHER, JERSEY CITY, N. J.

Mr. Schumacher also uses city water, for which he pays at the rate of $1.50 per thousand cubic feet. He applies the water by means of a single "water witch" at the end of hose of varying lengths. He irrigates chiefly celery, beets, and lettuce, and applies water to about seven to eight acres. The cost of water ranges from $100 to $150 per year. He has kept no record of the cost of its application other than the cost of water. His estimate of the net profits from irrigation is from $500 to $1,000 annually from the area mentioned.

W. W. RAWSON, ARLINGTON, MASS.

Mr. Rawson has irrigated market-garden crops for twenty-five years. His plant consists of pumps and piping. His pumps have a capacity of 2,000 gallons per minute, and when they are working to their full capacity it requires four men to handle them and apply the water when irrigating in furrows. When irrigating small garden truck it requires three or four times as many men, although usually some are using one method and some another. The water is drawn from a river and is usually pumped directly into the pipes, as he has only a small tank for storage for use in sprinkling and watering plants. Such crops as cabbage and squash are irrigated in furrows; whereas cauliflower, beets, onions, lettuce, celery, etc., are irrigated by means of an ordinary nozzle, a man holding his finger over the opening to form a spray. He has no definite figures as to the cost of his plant, since it is virtually a development from a small beginning twenty-five years ago, improvements being made from time to time as his business increases. He does not keep an exact record of the profits derived from the irrigation, but he states that crops are often increased 50 per cent, and nearly always as much as 25 per cent. He aims to apply an inch or two of water every two or three days on large crops where furrows can be used, but on small crops not so much is used at a time, but it is applied oftener.

W. H. ALLEN, ARLINGTON, MASS.

Mr. Allen uses a pumping plant which is not in first-class condition, as it has been used so long that the pipes are rusted and the pump is in poor condition. He therefore supplements his supply from the city mains. He uses the furrow method for cabbages, cauliflower, squash, etc., and sprays small plants with an ordinary nozzle. He has no definite idea of the cost of irrigation, as in addition to using water for irrigation he uses it for greenhouse work and for washing. He runs water on the land until it is thoroughly saturated. His records do not show the financial advantages of irrigation, though he knows that it pays well, and would not attempt to grow crops, in the dry season particularly, without irrigation.

HITTINGER BROTHERS, BELMONT, MASS.

This firm obtains its water from a brook and springs on the hillside above its land and the cost of irrigation is limited to the expense of piping and storage. The storage tank holds 50,000 gallons. Irrigation is confined entirely to strawberries. Watering is begun when the strawberries are small, using a 1-inch hose with an ordinary open nozzle, but when the berries are ripening the land is flooded. At each wetting about 10,000 gallons is used on 4.5 acres, or about $2\frac{1}{2}$ inches in depth. This is put on about once a week. One man can irrigate three or four acres in five or six days, and the cost is limited to the labor of the man. This year (1903) strawberries were irrigated four times before the drought ended, and would not have produced any fruit if irrigation had not been practiced. With irrigation 2,629 quarts were picked from 1 acre, and the berries sold at prices averaging a little more than 23 cents per quart, giving a gross return of more than $600 per acre. The firm has no definite idea of the cost of its cistern and piping and could not estimate the total cost of watering the berries, as the plant serves also to supply water to their greenhouses and washing tanks.

WYMAN BROTHERS, ARLINGTON, MASS.

This plant has been in operation for twelve to fifteen years. The original cost was about $5,000, but $2,000 has been spent on it since. The water is pumped from wells by the side of a lake and stored in a cistern with a capacity of 100,000 gallons. The cistern is used only when little water is needed for the greenhouses and ordinary washing. In irrigation proper the pumps are connected directly with the distribution pipes. One 4-inch main carries the water over the farm, and to this are attached 3-inch laterals. This system is arranged to cover 50 acres, only parts of which are irrigated each year, according to the crops. From the hydrants on the 3-inch laterals 2-inch pipes are laid on the surface, so that with 100 feet of hose, usually 1 inch, every part of the land may be reached. Cabbage, cucumbers, squash, and celery are irrigated by the furrow method, using hoe cultivation, but the lettuce, beets, onions, etc., are sprinkled. The plant is being run to its full capacity. There is one man at the engine, two or three men carrying pipes, and six or seven men using the hose, depending on the method used and the crop, or a total of from nine to twelve men. These irrigate, on the average, from 5 to 6 acres per day, putting on an inch of water, as nearly as can be estimated from the capacity of the pumps, which exceeds 10,000 gallons per hour. In dry weather the crops are irrigated every two or three days, or are given 2 or 3 inches per week, according to the crop. It is claimed by this firm that irrigation makes the difference between profit and loss on the market-garden crops that are grown, but there was no definite statement made as to the profits of the business.

F. H. COOLEDGE, WATERTOWN, MASS.

This is one of the largest of the plants described. It is possible to irrigate 100 acres, if necessary. While a number of small storage tanks of perhaps 11,000 gallons capacity are provided, these are not depended on. The pumps, with a capacity of 4,000 to 6,000 gallons per hour, are placed in driven wells and are connected directly with the distribution pipes, and connection with the cisterns is shut off. Mr. Cooledge aims to have 100 pounds of pressure, as part of his land is hillside. The sprinkling method of irrigation is used exclusively, a perforated nozzle being attached to a 1¼-inch hose. The crops irrigated include cabbage, lettuce, squash, radishes, beets, celery, carrots, peas, etc. When irrigating it requires one man at the pump and from eight to ten men at the hose. The water main to carry the water from the pump is 4 inches in diameter and is buried, but on the fields 3-inch pipes are laid on the surface of the ground, and are taken up in the fall and put down in the spring. The pipes are laid so that with 100 feet of hose every part of the farm can be reached. He estimates that from eight to twelve men will water eight to ten acres daily, depending on the crop and the method. In the fall he waters celery, even though he has showers every other day. He has no data concerning the cost of plant or of the labor involved. The expense, other than labor, when the plant is in full operation is equivalent to 1 ton of coal per day. He believes thoroughly in the advantages of irrigation and knows that it pays.

DAVID ASTLE, VINELAND, N. J.

The plant of Mr. Astle is located on the sandy soils of Vineland, N. J., and illustrates nicely the advantages of irrigation for such soils and for general market crops, including potatoes, beets, onions, tomatoes, celery, Lima beans, cabbage, etc. His supply of water is drawn from driven wells and is pumped into a tank and from thence distributed and applied by means of pipes and movable sprinklers. A form of sprinkler has been devised by Mr. Astle which is well adapted for use on level ground. The supply pipes run along one side of the field to be irrigated, and lateral pipes are attached at different points. A long pipe, supplied at intervals with spraying nozzles and extending across the field, is supported at a distance of about 6 feet from the ground by means of a framework and wheels. (Pl. I, fig. 2.) This is connected with the lateral pipe by means of a rubber hose, so that it can be pushed across the field. The ground is watered to the limit of the hose, when it is uncoupled and attached to the next tap on the lateral pipe, and so on. Mr. Astle began irrigating in 1899, trying it on an acre of cabbage. This was so successful that in 1900 he watered cabbage, potatoes, beets, onions, and other crops, with good results. A hayfield alongside of the irrigated plats received some of the water from these plats, and the crop was fully twice as heavy as that on the rest of the field. Irrigation has been continued with great success every year since. In 1903, on one plat of 1$\frac{7}{8}$ acres, Irish potatoes were grown first, followed by early celery. The total value of the two crops is estimated to have been about $800. This, of course, was not accomplished without heavy manuring, although it shows the possibilities of this light land when abundantly supplied with water.

F. W. KILBOURNE, NEW BRUNSWICK, N. J.

This plant is located within the limits of the city of New Brunswick. The supply pipe from the pumping station to the city reservoir runs through the farm. This pipe is tapped and water obtained direct from the reservoir at a cost of $1 per thousand feet. The area under irrigation is from 2 to 3 acres and is under intensive cultivation. Early cabbage, cauliflower, beets, onions, celery, spinach, and lettuce are chiefly grown. The land is always thoroughly saturated previous to setting plants, and irrigated afterwards as needed. The furrow system is used except for lettuce, which is sprinkled. The land has a slight fall, sufficient to carry the water slowly, and whenever irrigation of crops is practiced about 2 inches are applied and the land is immediately cultivated to retain the water. The cost of the water does not exceed an average of $25 per year, and when three crops are grown the average gross value is $1,500 per acre.

GEORGE A. MITCHELL, VINELAND, N. J.

The chief object of the year's work has been to perfect a low-priced pumping irrigation plant, in which the water is distributed mainly by gravity, but on occasion by sprinkling. The experience of the past six years shows that for gravity distribution the most important requisites are a large volume of water and the appliances necessary to deliver it at just the right time. These requisites have been secured in the past by pumping directly to the field with a 2½-horsepower gasoline engine and centrifugal pump, by which 100 to 125 gallons per minute can be delivered at the highest point of land on the farm.

In previous years the main pipe has been a homemade, tarred-cloth hose supported on poles. The poles began to weaken in 1902, so they were taken down and some 4-inch cast-iron pipe, taken from a greenhouse, was laid for a main. Near the top of the hill, where there was very little pressure, terra-cotta sewer pipe was used; some of this pipe was put together with Portland cement, some with oakum and red lead. The water is pumped with the same engine and pump formerly used, a little over 100 gallons per minute being delivered at the top of the hill. This pipe is just enough below the surface of the ground to allow plowing over it.

To secure the two conditions mentioned, a pond holding 50,000 gallons has been excavated at the highest point and the water empties into this through the iron pipe. There are three outlets of 2-inch pipe for letting out water when only a small volume is needed, and one outlet of 8-inch pipe which supplies the larger portion of the land to be irrigated.

Having secured a satisfactory water supply for irrigation, the next problem is the distribution of the water. The 10 acres which it is desired to irrigate slope in two general directions. On the main slope, however, there are two knolls, one of which has always interfered with irrigation in two ways. The water must be taken to the top through a long line of hose, and then if enough water is used to wet the top of the knoll the low ground will be too wet. By moving about 100 cubic yards of earth from the hill into the hollow both difficulties will be done away with and water will flow 750 feet, rendering 4 acres subject to easy irrigation by gravity. This work is partly done.

The other knoll mentioned is 2 feet higher, and there are fruit trees growing on it. Although the same difficulties exist there that have been mentioned concerning the other, the slopes are longer, and consequently the difficulties are not so great.

The objection is often heard that gravity irrigation will do in a few places, but that most farms in South Jersey are too flat. To test this, 1 square mile of the surrounding country was examined as to slope of land, and it was found that three-fourths of it has sufficient slope to render irrigation by gravity easy, while nearly all could be successfully irrigated by gravity if some leveling were done.

It is sometimes desirable to sow clover seed at a certain time; for instance, crimson clover needs to be sowed among squash or cantaloupe vines just as the runners start. Often the ground can be thoroughly wet by gravity irrigation, but sometimes it would be a great advantage to sprinkle. In view of this fact a low-wheeled wagon was purchased, to be used as a lumber wagon and, when occasion required, for mounting the engine and pump and hauling them into the field to be irrigated. The water can be brought to the pump in a ditch and carried to the sprinklers through several lines of hose. Since a centrifugal pump is used, it does no harm if the water is a little sandy.

The arrangements for the irrigation of the 10-acre farm are now such as the experience of six years would indicate as best for a low-priced irrigation plant. This plant could be duplicated for $325 if second-hand pipe could be secured as cheaply as was that now used. This estimate includes labor.

C. BECKER, VINELAND, N. J.

Mr. C. Becker has irrigated small plats of land for several years. After trying many methods of distributing water he decided to try sprinkling, as requiring the least labor. One-seventh acre was fitted with parallel 2-inch pipes laid 11 feet apart, and "water-witch" sprinklers were attached at distances of 20 feet. (Pl. II, fig. 1.) The cost of 4,000 feet of 2-inch pipe, at 12 cents per foot, and 200 sprinklers, at 50 cents each, would be $580 per acre. Reckoning interest plus the depreciation of the plant at 10 per cent of the cost, the annual cost of irrigation would be $58 per acre, not counting original cost of pumping plant, which is used for other purposes as well as irrigation, nor cost of attendance while irrigating, nor cost of pumping. The entire device is arranged to sprinkle without heavy expense of attendance. If greater pressure were used, the cost for pipe and sprinklers could be reduced about one-half, as shown in the description of Mr. Astle's plant (p. 14).

The water is supplied from a tank 10 feet deep placed 15 feet above the ground. The water is pumped into this tank from a well by a windmill when there is wind or by a gasoline engine when the wind fails.

In 1903 the original plan of growing three crops on this ground was not carried out on account of pressure of other work. Strawberries,

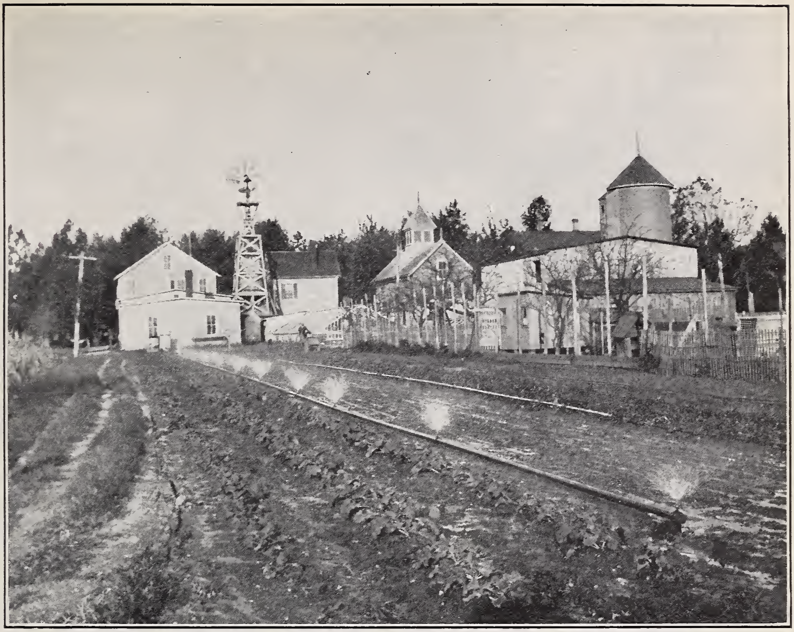

FIG. 1.—METHOD OF DISTRIBUTING WATER USED BY C. BECKER, VINELAND, N. J.

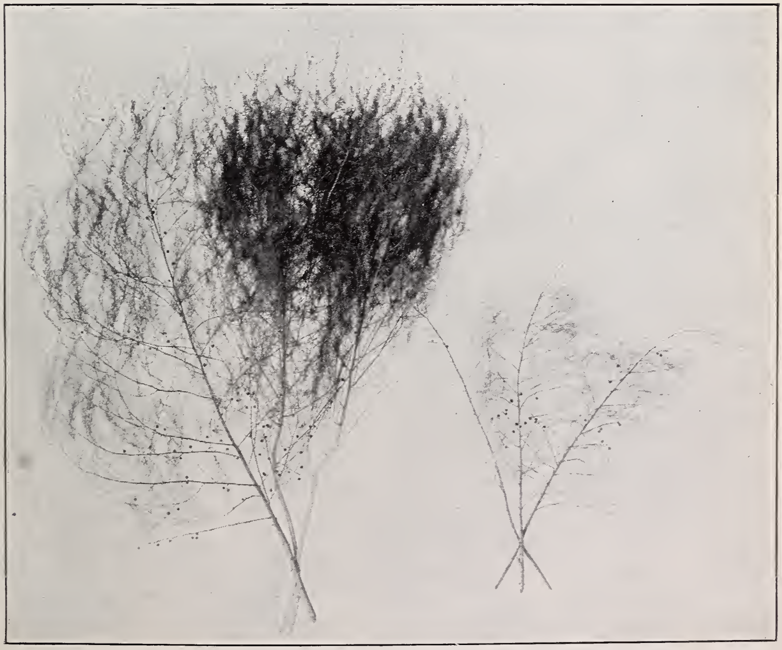

FIG. 2.—ASPARAGUS PLANTS FROM IRRIGATED ROW ON THE LEFT, FROM UNIRRIGATED ROW ON THE RIGHT.

beets, and onions were grown. Strawberries set out the last of September, 1902, grew so well under irrigation during the drought in the spring of 1903 that hundreds of plants yielded one quart each, the growth in many cases being so rank that some large berries ripened under the foliage while still having the green color.

Mr. Becker thinks he irrigated too frequently and by doing so caused too rank a growth. Every berry that set was ripened, there being no dried-up and spoiled fruit, as is common in this section. In the case of onions and beets the value of irrigation was shown by the fact that every plant produced a salable article. There is hardly a year when it is not too dry for onions and beets for at least a short time during the latter part of their growth.

Onions and spinach have been planted this fall (1903) preparatory to growing three crops next year and testing the full capacity of this method of gardening with the help of irrigation.

IRRIGATION EXPERIMENTS IN NEW JERSEY IN 1903.

By Edward B. Voorhees,

Director New Jersey Agricultural Experiment Stations.

ASPARAGUS, BLACKBERRIES, RASPBERRIES, GOOSEBERRIES, CURRANTS, AND STRAWBERRIES.

The experiments in progress to study the influence of irrigation upon these crops were continued this year, though the records of rainfall and evaporation, as given by the table which follows, show very clearly the reasons why no real advantage was obtained from the work.

Record of evaporation from water tanks at New Brunswick, N. J., July, 1902, to July, 1903.

Dates of reading	Gain (+) or loss (−) of water in tank.	Rainfall.	Loss of water by evaporation.
1902.	*Inches.*	*Inches.*	*Inches.*
July 19	−1.93	0.44	2.37
August 2	+ .55	2.54	1.99
August 16	+1.70	4.51	2.81
August 30	− .15	1.57	1.72
September 13	− .30	1.32	1.62
September 27	+1.95	2.81	.86
October 11	+2.93	5.41	2.49
October 25	+ .80	1.65	.85
November 8	+ .85	1.90	1.05
1903.			
March 7 (started)		---------	---------
March 21	+1.56	2.51	.95
April 4	+1.69	2.97	1.28
April 18	+2.45	3.83	1.38
May 2	−1.90	---------	1.90
May 16	−1.98	.18	2.16
May 30	−2.10	.11	2.21
June 13	+1.60	3.72	2.12
June 27	+1.65	2.87	1.22
July 11	+ .68	1.18	1.86
Total	---------	39.52	30.82

It will be observed from a study of the table that the rainfall exceeded the evaporation during the growing season by 8.70 inches. This is the first year since the tank was established that the evaporation has not exceeded the rainfall. In 1900–1901 the evaporation exceeded the rainfall by 8.66 inches, while in the same period of 1901–2 the evaporation exceeded the rainfall by 1.52 inches. It will be noticed also that the only serious deficiency in rainfall occurred in May. This drought was accompanied by cool weather; hence, while growth was retarded, it was due quite as much to the low temperature as to the lack of water. This was clearly proved by the results obtained in the application of water, particularly in the case of asparagus. This being the earliest crop, the harvest season of which is the latter part of April and the months of May and June, would naturally be more seriously affected by a lack of water and consequently more benefited by its application, other things being equal, than crops coming on later. Nevertheless, it was shown that the application of water did not result in increasing the yield of the crop. Evidently the low temperature prevented a proper growth and development, even with an abundance of water. Water was also applied to blackberries, raspberries, gooseberries, currants, strawberries, and fruit trees; and while the records were faithfully kept, they show that no advantage was derived from the addition of water. This result was also due in large part doubtless to the fact that the growth through May was not retarded by lack of water, but by the low temperature. Inasmuch as the results do not show any particular effect, they are withheld from publication until further data are obtained.

IRRIGATION DURING THE SEASON OF 1903 AT MISSOURI AGRICULTURAL EXPERIMENT STATION.

By H. J. WATERS, *Director.*

During the season of 1903 the cooperative experiments in irrigation were continued with strawberries, asparagus, nursery stock (consisting of apple, peach, and plum trees), and onions.

The season taken as a whole may be said to have been favorable for growing crops, although the excess of moisture during the late spring and early summer was a detriment to farm work for a time. The summer was cooler than usual throughout, with the exception of May and July. The first part of April was warmer than usual, but during the latter part of the month the weather was generally cool, with heavy frosts on the 23d and 26th. The mean temperature of the month was 54.9° F., or 1.5° below the normal. The precipitation exceeded the normal by 1.68 inches and was fairly well distributed. The first week of May was unseasonably cool. A killing frost occurred on the first, but the remainder of the month was warm, with frequent showers. The mean temperature was 65°, or 0.5° above the normal. The rainfall was abundant, being slightly above the normal for the month. June was exceptionally cool and dry, the mean temperature (66.4°) being 7.9° below the normal, while there was less than half the usual amount of precipitation. July averaged slightly warmer than usual, the mean temperature being 77.3°, or 0.9° above the normal, while the precipitation was markedly deficient, being 1.91 inches below the normal. August was cool and showery, the mean temperature (73.9°) being 2.1° below the normal, with about double the usual amount of precipitation. The following table gives the precipitation for the season at Columbia, Mo.:

Precipitation, April-August, 1903, at Columbia, Mo.

Day.	April.	May.	June.	July.	August.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1	----------	----------	0.08	----------	0.05
2	----------	----------	.20	Trace.	.10
3	1.39	----------	.06	0.18	----------
4	----------	----------	.09	.02	----------
5	----------	0.28	.06	----------	.01
6	----------	Trace.	----------	----------	.65
7	.03	.01	----------	----------	.01
8	----------	----------	Trace.	----------	.24
9	----------	Trace.	.13	----------	----------
10	.32	Trace.	----------	----------	----------
11	.23	.33	----------	.80	.07
12	Trace.	.04	----------	.01	.58
13	.01	.23	----------	----------	.91
14	.06	.01	----------	01	----------

Precipitation, April-August, 1903, at Columbia, Mo.—Continued.

Day.	April.	May.	June.	July.	August.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
15	Trace.				
16	0.01		0.01	0.13	Trace.
17		0.09		.03	
18	.02	.03		.62	
19	.98	.13	.58		Trace.
20	.70	Trace.			
21		.37	.01	.53	
22			.33	Trace.	
23		.05		.01	
24	.02	.04			Trace.
25		1.96	.02		0.24
26		Trace.	.57		.88
27		.06	.02		.47
28					.88
29	.14	.24		.02	Trace.
30	.75	.28			
31		1.11		Trace.	
Sums	4.66	5.26	2.16	2.36	5.09
Departure from normal	+1.68	+0.31	−2.71	−1.91	+2.57

Irrigation was not begun on any of the crops except onions until August, because showers had been frequent and the soil seemed to be fairly well supplied with moisture.

STRAWBERRIES.

The value of irrigating an old strawberry field having been fully demonstrated heretofore in these tests, this experiment was planned to determine the effects of watering a young plantation of the vines. The plants were set in the spring and given good culture throughout the season until the irrigation began. In a few rows there was a poor stand, owing to some of the plants having been injured in transplanting. Also, this being a partial test of some, a few of the newer varieties planted proved to be weak growers.

The rows were 4 feet apart and the plants as set stood 2 feet apart in the rows. The irrigating ditches were made by opening a furrow beside each row of plants with a single-shovel plow. This plan was favored because the ground sloped gently from near the center toward both sides—the east and the west—as well as toward the south, the direction in which the water was to flow. The furrows being as near the rows as possible and always on the upper sides, no difficulty was experienced in saturating the soil about all of the plants. When the plants had made a good growth the runners had covered nearly all the spaces in the rows between the original plants, and in some parts of the plat there were solid mats of plants as much as a foot wide.

The water used was secured from the city waterworks system, and was conducted through pipes and hose and fed into a trough, from which it was distributed uniformly into six furrows at a time.

Water was first turned into the strawberry field on August 3, and was allowed to flow at intervals for five days. The area irrigated was about one-seventh of an acre, and there was a total of 20,000 gallons of water applied, sufficient to cover the irrigated area to a depth of 5.27 inches.

As soon as possible after irrigating the ground was smoothed down and stirred with a light cultivator. Within a few days after watering there were showers, which appeared to leave the unirrigated soil as wet as that which had been irrigated. It was noticeable later in the month, however, that there was more moisture in the irrigated plats, although it is to be remembered that there was no serious deficiency of moisture at any time during the month where there had been no irrigation. While there were no noticeable differences in the growth and vigor of the plants where irrigated and not irrigated during the remainder of the season, it should not be said at this time that there were no beneficial effects from the watering. It appears that the critical period of the season for the strawberry plant is during the month of August. It is found that if water is applied in August in a dry season a good yield of fruit is secured the next summer, but it remains to be determined whether an abundant supply of water furnished artificially is of more value to the plants than a moderate amount supplied by natural precipitation. In other words, it can not be determined definitely until after the next fruiting season whether it will pay to irrigate in a season of medium or abundant rainfall.

Except for the watering, the irrigated and unirrigated plats were given precisely the same treatment throughout the summer and fall, and all of the plants were mulched alike during the winter.

ASPARAGUS.

A part of the asparagus bed mentioned elsewhere in this report was irrigated during the season of 1903. Two rows were selected to be watered. These rows represented average conditions throughout the field. The soil was in good tilth and in splendid condition for retaining moisture, having received each fall for three or four years a heavy dressing of composted barnyard manure, which was worked into the soil by the spring cultivations. The plants were 7 years old and were in prime condition as to vigor. The rows were 4½ feet apart, and the plants were growing thickly in the rows in a mass 12 to 16 inches wide. The land slopes gently toward the south. Furrows around each row were made with a single-shovel plow, working as near the plants as possible without injuring them. At the upper end of the rows a cross ditch was provided for feeding the furrows. The water was allowed to flow in the furrows until the soil was thoroughly saturated. The total amount of water applied to the asparagus during the two days August 10–12 was 2,200 gallons, amounting to a depth of 2.39 inches over the area irrigated, about one thirty-sixth of an acre.

Frequent showers came after irrigating, so that it was not thought necessary to apply any more water. Although the rains kept the soil supplied with more than the normal amount of moisture during the remainder of the month, as well as in September, the irrigated rows showed the beneficial effects of the extra water they had received. Within two weeks after being irrigated, even in the presence of heavy showers which seemed to wet the ground thoroughly, the artificially watered rows began to show signs of being reinvigorated. New shoots began to appear among the old stocks, and the branches of the mature plants showed new activity by appearing green at the tip of every branchlet. In marked contrast to the irrigated plat, the unirrigated rows began to show the usual signs of closing the season's growth by the gradual dying of the inner branches. With the waning of September the brownish appearance was quite noticeable, while the irrigated plants continued green.

Upon closer examination it was discovered that the unirrigated rows were affected with asparagus rust (*Puccinia asparagi*), while the irrigated plants were entirely free from the disease. This was to be expected, as observations recorded by a number of investigators have shown that rust is most destructive in seasons and soils where the plants suffer for moisture. On the other hand, any condition producing too great an amount of moisture about the plants is injurious to them, since the rust is likely to injure plants weakened by excess of moisture as well as by too little.

It is well known that asparagus requires a moist soil for its best development; but the advice of recognized authorities has usually been against late summer or early fall mulching to conserve the moisture, as such treatment was believed to favor the appearance of the rust. That the disease is not aggravated by irrigating in late summer is thoroughly proved by the test just completed. A careful estimate of the extent of the rust disease among the irrigated plants places it at one-half of 1 per cent. An inspection of the unirrigated rows showed that fully 90 per cent of the stems of the plants had died, probably from the effects of the rust.

In Plate II, figure 2, is shown the difference in size and appearance of the irrigated asparagus plants and those not irrigated, the stalks on the left being only average specimens in point of size and are free from disease. The group of small plants on the right was not irrigated. They were not only small, but were badly affected with rust. Plate III, figure 1, shows a near view of sections of some of the asparagus stalks seen in Plate II, figure 2. Those on the left were small, and the disease was very noticeable, as indicated by the blotches and irregularities in the bark. The stalks on the right were irrigated, and were large, clean, and healthy.

When the soil is deficient in moisture, late summer application of water to asparagus will invigorate it sufficiently to cause it to resist rust and enable the root stalks to store up a surplus supply of food materials that will enable them to push up the young edible shoots quite early in the spring that will be both vigorous and abundant.

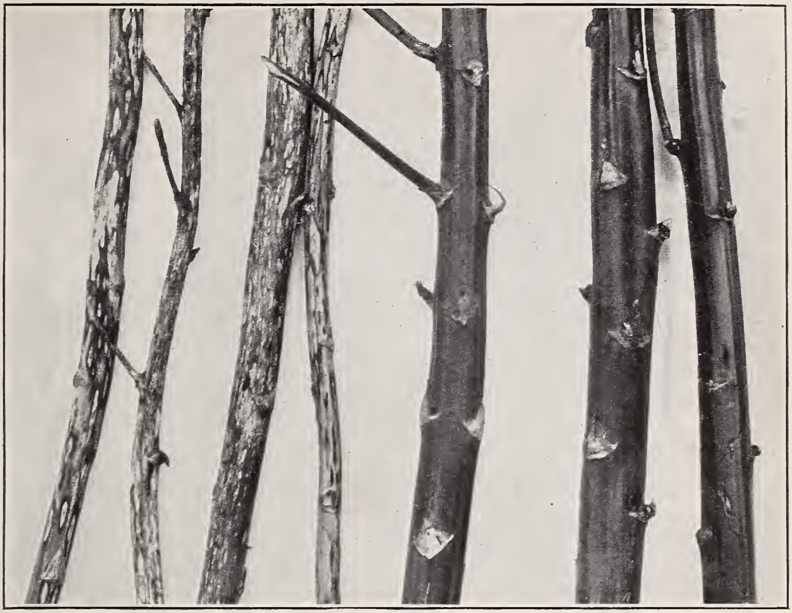

FIG. 1.—EFFECT OF IRRIGATION ON ASPARAGUS DURING AN ORDINARY SEASON; UNIRRIGATED STALKS (ON LEFT) BADLY AFFECTED BY RUST.

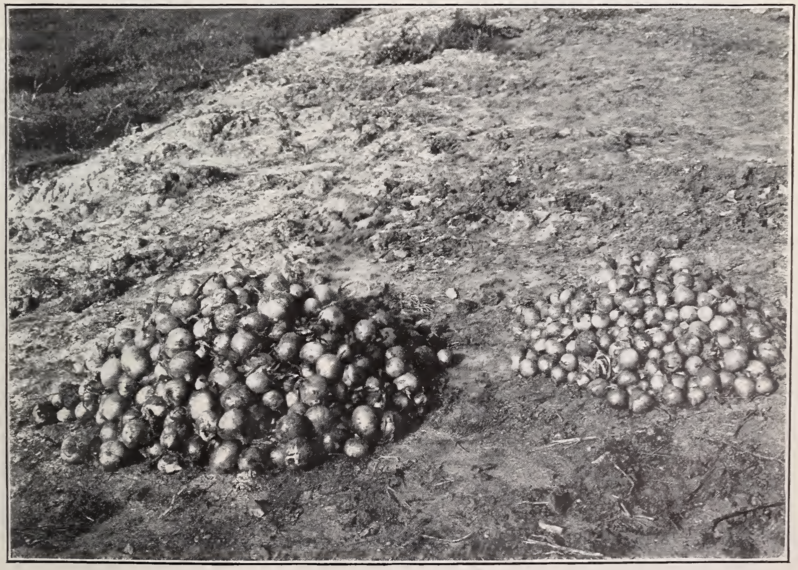

FIG. 2.—YIELDS OF ONIONS ON IRRIGATED PLAT (ON LEFT) AND ON UNIRRIGATED PLAT (ON RIGHT).

NURSERY STOCK.

The nursery stock irrigated during the season of 1903 consisted of 2-year-old apple trees of many varieties, and seedling peach, cherry, and plum trees grown as stocks for budding.

Water was applied from August 7 to 11. With a single-shovel plow furrows were made around each row as near the trees as possible. The irrigated plat was laid off in the middle part of the nursery and represented average conditions in every respect. The water was conducted to the plat through pipes and discharged into a cross ditch at the upper ends of the rows. From the cross ditch the water was emptied into the various furrows uniformly, so that all were equally watered and none overflowed. No water was wasted. The soil was saturated.

The total quantity of water used on the one-tenth of an acre irrigated was 12,400 gallons, equivalent to a depth of 4.67 inches.

Rains came shortly after the irrigating was done, and apparently minimized its results. There is perhaps a slight tendency on the part of the trees irrigated to continue their growth later in the season, thus showing that they have been influenced to at least a slight extent. November 2 the irrigated trees were not appreciably larger than those not irrigated; but as the irrigated ones seem disposed to continue their growth, they may yet outstrip the unirrigated. Nursery trees here may continue to grow until December if they have sufficient moisture.

ONIONS.

Four varieties of onions were experimented with. The soil was a deep, unusually fertile clay loam. The seed was planted May 7 in drills 16 inches apart. The young plants received careful cultivation all during the season. The month of July was the driest and warmest of the season. The land sloped gently toward the south. Shallow irrigating ditches, about 3 inches deep, were made by using the corner of a common garden hoe. There was one furrow down the middle of each space between the rows, making them 16 inches apart. At the upper ends of the rows was a cross ditch, and from this water was fed out uniformly to several furrows at a time. The block to be irrigated was laid off near the middle of the garden, part of the onion planting being left unirrigated for purposes of comparison. The water was conducted over the unirrigated plat through pipes and hose, so that there was no opportunity for seepage into the wrong plat.

The irrigating was begun July 27, the water being allowed to flow until the soil was well saturated. A total of 2,500 gallons was applied, amounting to a depth of 6 inches over the area irrigated—about one-sixty-fourth of an acre. When the water had settled the soil was stirred to prevent baking.

The crop was harvested the first of September, and a careful record kept of the yields under different conditions. There were equal areas in the irrigated and unirrigated plats. Each variety on being harvested was weighed, so as to show the total yield both under irrigation and where not irrigated, and then the product was divided into three grades, where the bulbs were large enough to make this possible. In this way were secured the actual comparative effects of the watering, as shown in the accompanying tables:

Effects of irrigation on size of onions.

Variety.	Treatment.	Large.		Medium.		Small.		All grades.	
		Weight.	Number per pound.	Weight.	Number per pound.	Weight.	Number per pound.	Weight.	Number per pound.
		Lbs. ozs.		*Lbs. ozs.*		*Lbs. ozs.*		*Lbs. ozs.*	
Silver King	Irrigated	7 10	4	7 12	10	11 6	25	26 0	12
	Not irrigated	4 10	7	4 10	11	6 2	28	15 6	14
White Portugal	Irrigated	16 2	5	20 8	9	14 8	26	51 2	14
	Not irrigated	12 6	6	12 8	9	13 8	26	38 4	13
Red Wethersfield.	Irrigated	20 8	5	20 8	7	10 10	17	51 10	11
	Not irrigated	16 6	5	20 8	8	20 10	20	57 8	9
Danvers Yellow Globe.	Irrigated	95 0	3	49 8	5	33 6	13	177 6	7
	Not irrigated	29 10	5	48 0	8	28 6	18	106 0	11

Effects of irrigation on yield of onions.

Variety.	Treatment.	Yield.	Value.	Yield per acre due to irrigation.	Percentage of increase due to irrigation.	Value per acre of increase due to irrigation.
		Bushels.		*Bushels.*	*Per cent.*	
Silver King	Irrigated	52.18	$26.09	22.80	77.6	$11.40
	Not irrigated	29.38	14.19			
White Portugal	Irrigated	94.90	47.45	19.27	25.4	12.70
	Not irrigated	75.63	37.82			
Wethersfield	Irrigated	50.06	25.03			
	Not irrigated	56.06	28.03			
Danvers Yellow Globe.	Irrigated	172.00	86.00	69.50	67.60	34.75
	Not irrigated	102.70	51.35			

It is at once apparent that in most cases the yield was materially increased by watering, although in one instance—the Red Wethersfield—the total yield was slightly greater on the unirrigated plat. If this exception is studied, however, it will be seen that, although the total number of pounds was less on the irrigated soil, more small and fewer large onions were produced on the unirrigated soil. In this connection, also, it should be stated that the Wethersfield onion is a variety well known to be drought resistant, and hence would naturally be less influenced by artificial watering than the others.

Yellow Globe, which requires a moist soil, gave a remarkable increase in yield, due to irrigation. (Pl. III, fig. 2.) The test shows that in almost any season onions may be irrigated with large profit to the farmer or gardener.

CORN.

The season of 1903 was not sufficiently dry in the vicinity of Columbia to show any remarkable differences between irrigated and unirrigated crops. The actual irrigation of corn was not begun until August 14. Up to that time moisture conditions had been fairly favorable for the development of the corn crop. From the above date the water was turned on from a ⅞-inch pipe and was allowed to run continuously for two weeks. In nearly every case the irrigated plats gave larger yields than those not irrigated. Computing the yields per acre from the plat yields we find that the irrigated corn produced at the rate of 63.5 bushels of grain and 4,630 pounds of stover per acre, and the unirrigated at the rate of 58.3 bushels of grain and 4,315 pounds of stover per acre. This is a difference of 5.2 bushels of grain and 315 pounds of stover per acre in favor of irrigation. The influence of irrigation upon corn is not limited entirely to the gross yields per acre. The irrigated corn seemed to be better filled and the individual grains were plumper. The irrigated corn was considerably slower in maturing than the unirrigated. The stalks grew taller on the irrigated than on the unirrigated plats. The water used in this experiment was surface water from a pond. It is believed that the results would have been considerably more favorable for the irrigated plats if the irrigation had been started earlier.

IRRIGATION IN THE ARTESIAN BASIN OF SOUTH DAKOTA.

By A. B. Crane, *Special Agent.*

INTRODUCTION.

The great artesian basin of South Dakota comprises that area in which flowing wells have been obtained by drilling down into the Dakota sandstone formation that underlies almost the entire State. Owing, however, to the greater number of wells and to the ease with which artesian water can be obtained there, the locality comprised in the James River Valley has become more familiarly known as the artesian basin. It is within this area that most of the experiments in irrigation from artesian wells have been conducted.

The eastern limit of the artesian area is a line about 25 miles east of the James River and approximately parallel to it to a few miles south of Mitchell, from which point it bears southeast, following the course of the river to its mouth. West of the James River artesian water can be obtained almost anywhere except at a few points where the elevation does not allow the water to rise to the surface, as in the Wessington Hills or in the Missouri Coteaus east of Gettysburg. Owing to the fact that the portion of the country west of the James River Valley is given over largely to stock raising, the wells there being used entirely for stock purposes, the work in irrigation is restricted to the valley skirting to the east of Wessington Hills before finally bearing off toward the Missouri.

During the period from 1890 to 1894 quite a number of wells were sunk with the intention of using them for irrigation. Their great expense (from $2,500 to $4,000) restricted their construction to a few persons with large means or to corporations. The wells were mostly 6-inch wells, with depths varying from 1,300 feet in the region of Aberdeen to about 500 feet at Yankton. Few of them, however, owing to various circumstances, have ever been used. The lands were placed in the hands of tenants, most of whom knew nothing of irrigation. The work was spasmodic and without any system or knowledge of the use of water. Of course such attempts could result only in financial loss to the original projectors, so they were given up.

Within the last year or two a new system has been adopted—the sinking of small 1¼ to 2 inch wells. These can be sunk much more cheaply, the price ranging from $300 to $650. Resident farmers find it within their means to sink these wells, and many of them are being sunk throughout the basin.

Though at present used for stock and household purposes, great numbers of them have been located with reference to a possible utilization for irrigation purposes if needed in the future. It is to these wells in the hands of the actual owners and users to which we will doubtless have to look for the future development of irrigation rather than to the larger wells owned by the corporations and nonresidents.

As shown on page 44, the annual rainfall of this region has varied during the last eight years (1896–1903) from less than 13 to over 26 inches, the average being about 19 inches. This is sufficient for many crops when favorably distributed, but seasons of drought have been sufficiently frequent to lead to the construction in many localities of reservoirs, canals, etc., for the utilization of the artesian water for irrigation.

An investigation during the season of 1903 shows that during the last few years there has been an abundance of moisture, well distributed and fully sufficient for all the ordinary grain crops; hence many farms with full equipment of well, reservoir, ditches, etc., have not used the water supply at all, many not even cleaning out their ditches for the last six or eight seasons. As a consequence, most of the positive results that have been reported are from small areas devoted to gardens, fruits, orchards, and forests.

Many of the irrigation plants mentioned in the reports of 1895 and 1896 as being in successful operation have been practically abandoned, and no report can be found for them subsequent to those made at that time. Many of the farms have changed hands, some have fallen into the possession of large land companies, and some of the wells have failed. In general, those who have most thoroughly and systematically tried irrigation are the most enthusiastic regarding it, while reasons for the failure of most of those condemning it can be found in the faulty method of operation.

A detailed report of what is now being done in the different counties of the artesian basin follows.

AURORA COUNTY.

The Smith-Jones farm, about 5 miles east of Plankington, formerly owned by J. D. Bartow, has a 3-inch well, 756 feet deep, discharging 150 gallons per minute; a reservoir about 2 acres in area, which can be filled to a depth of 5 feet, and about a half mile of main ditch. Eighty acres of this farm is situated so that it can be put under ditch. Mr. Bartow sold the farm several years ago and reports nothing done since 1895, but previous to that he irrigated 35 acres with decided success. He raised corn, potatoes, and melons in great abundance, and made a great increase in the grain crop by the use of the water. He estimates that the yield of small grain is doubled in ordinary years, while the yields of potatoes and garden crops are even more largely increased. Mr. Bartow gives as the reason the irrigation plant on this farm has fallen into disuse that it has fallen into the hands of tenants, usually men from the East unacquainted with and afraid of irrigation, and who make no effort to use water. His own success while operating the farm leads him to speak very enthusiastically of the possibilities of irrigation in that section.

J. W. Mullen, on section 24, township 105 north, range 66 west, conducted an irrigated garden with success several years ago; but the well has since failed, so irrigation is not practiced at present.

John Davis, on section 12, township 105 north, range 65 west, has a 1¼-inch well, 924 feet deep, flowing about 60 gallons per minute. He has irrigated trees and has been able to grow them successfully where before he could not make them grow. He runs the water direct from the well. Mr. Davis has attempted gardening with varying success. His great difficulty arose from the fact that often just after irrigating a heavy storm would come, thus making the soil too wet and injuring the crops. A crop of watermelons was spoiled in this manner. Mr. Davis intends to arrange ditches so it will be possible to use the well for irrigation when needed, but so far he reports an abundance of moisture for his small grain and no need of the extra water except for his trees and garden.

Mr. C. L. Mott, on section 15, township 105 north, range 64 west, 14 miles north of Plankington, is conducting a farm which, though not irrigated, strictly speaking, is, to a certain degree, receiving the same benefits. He has three wells on his farm, all 2-inch wells at the surface, finished below with 1¼-inch pipe. They are 840 feet deep and flow, respectively, 100, 72, and 15 gallons per minute. Mr. Mott is developing an orchard. He has 15 acres of 2 and 3 year old trees just beginning to bear, and 6 acres more set out this year. The orchard contains apples, plums, cherries, pears, and peaches, the last two being experiments, but he thinks they are going to succeed, especially the pears. Mr. Mott does not apply water directly to his land, but he has ditches and pools filled with water, and the seepage and the evaporation seem to fully supply the deficiency in the natural moisture. The wells are finely located for irrigation, and if a series of dry seasons occur he intends to use the water directly, if necessary.

A. D. Dougan, living on section 21, township 104 north, range 63 west, 8 miles northeast of Plankington, has a 4½-inch well, 523 feet deep, which flows about 80 gallons per minute. He has a natural lake bed on his land from which he can irrigate about 30 acres. He irrigates his orchard and garden from the well, and is having good success with his trees, though they are still young and have just begun to bear. Mr. Dougan has been well pleased with his irrigation of potatoes, having raised 230 bushels per acre. He has never used the water on small grain, and did not use it at all this season, as there was plenty of rain.

Many farmers in this county having small wells for stock purposes water their home gardens, and town residents having access to hydrants use water on their gardens and lawns, thus raising good gardens, trees, and shrubbery much more successfully than without the water.

BRULE COUNTY.

During the years from 1891 to 1895 Brule County entered quite extensively into the sinking of wells and the construction of ditches, the county and townships undertaking the work with a view to renting water. The wells were not utilized to any extent, and, the seasons having been more propitious, they are now used merely to supply lakes and furnish water for stock.

W. A. Carpenter, on his ranch at Pukwana, began irrigating in 1894–95, using water on small grain; but the price being low and the seasons being favorable he found that under the method of hiring his work done he could not conduct the business on the large scale he had planned without financial loss, so he abandoned operations.

J. M. Green and H. L. Wilrodt, living 12 miles south of Pukwana, have also ceased to use their water except for trees and gardens.

R. F. Jones, on section 5, township 105 north, range 67 west, has a 3-inch well about 600 feet deep, furnishing about 50 gallons per minute. He stores his surplus in a reservoir and irrigates alfalfa, receiving a large yield each season.

BEADLE COUNTY.

Beadle County was one of the few in which townships undertook the sinking of wells, Bonilla and Richland townships each having sunk them with the intention of using them for irrigation. The Richland township well, located on section 29, township 110 north, range 60 west, 4 miles south of Cavour, is a 6-inch well 930 feet deep, and the official test at the time of its acceptance by the township authorities showed a flow of 876 gallons per minute. The well is admirably located upon a high point, and water can be carried in all directions. A large ditch runs south for 1½ miles, and another running north about the same distance has been contemplated but is not yet constructed.

Part of this ditch is 20 feet wide and is intended for storage purposes in lieu of a reservoir. The method of disposing of water from this well was to contract with different individuals for the whole flow for one day each week throughout the season. The charge for the most successful season was $35. The next year each of the seven days was contracted for at $50 for the season, but dissatisfaction on the part of some who wanted water at a lower price than those who gave $50 created dissension, the personnel of the township board was changed, and many of those who contracted did not use the water. This was in 1896; nothing has been done since. The water now runs into a natural lake bed and thence to a neighboring creek. The cost of this well was $3,500, and of the ditches about $250.

The ditches are located so that about ten quarter sections can receive water. There appears to be a good natural reservoir here which would hold all the winter's flow, rendering it available for the next summer, though a few cuts, possibly 10 feet deep, would be needed to carry the outflow to some of the land. By this means at least two additional sections could be irrigated from this well. All those who formerly used water from this well have since sold out and moved away. The man who most successfully used water was Mr. M. O. Bessernd, who reported yields during the two years he used the water, as follows: Wheat, 30 to 32 bushels per acre; onions, 250 bushels per acre; oats, 60 to 90 bushels per acre; and large amounts of garden vegetables; this, too, in a dry year (1895) when the unwatered crops were almost a failure. He was well pleased with his results, and made this statement at the close of his report to the State engineer of irrigation: "I am more than pleased with the results of my first year's irrigating, and will never again be caught at dry farming when water can be had."

The wells in Bonilla township (township 113 north, range 64 west), though intended for irrigation, have never been used except to flood the pasture land and so increase the feed. No one seems to care to attempt farming by irrigation from them.

The most successful irrigators in Beadle County are the Joy Brothers, who operate a large market garden near Huron. Their land is located on section 18, township 110 north, range 61 west, 2 miles south of Huron. They have a 3-inch well 825 feet deep, which furnishes about 150 gallons per minute, and have about 100 acres under irrigation. They store water in a reservoir covering about 5 acres, which they can fill to a depth of 4 feet. This is used on a field of about 30 acres on the river bottom, the main gardens being irrigated directly from the well. The water is carried through 4-inch tile pipes laid to grade with cemented joints, so that no water is lost. At intervals tees or elbows are put in, a short piece of iron pipe being cemented in, in which a screw plug is placed. Water is let out when wanted by removing this plug and is carried in open ditches to the place of use. This pipe cost about 10 cents a foot placed, and Mr. Joy says it is one of the most paying investments on the farm. It was laid in the old open ditch and mounded over about 2 feet deep, the ridges forming paths through the fields.

The cost of applying water to the land—that is, the labor of distributing it—is about $1.25 per acre per year. The cost of ditching is merely nominal, as a plow furrow in the proper direction is all that is needed. Joy Brothers have conducted this garden since 1896 and have met and overcome many of the difficulties which others have experienced. They are careful not to use too much water and so drown out the crop; they let no water stand on the land, but keep it running till it is all soaked in; they use manure freely; they cultivate soon after irrigating. Crops from this garden average about $200 per acre, though Mr. Joy could make no detailed report on the separate varieties. Potatoes yield about 200 bushels per acre; cabbage, 5,000 to 7,000 heads per acre; onions, 300 bushels per acre, and strawberries, 200 bushels per acre. They raise no small grain under irrigation, but grow corn on ground which has been irrigated the previous year, drawing upon the subsoil moisture, which is sufficient for the crop, and in this way the yield is nearly double that of corn not irrigated. They are troubled somewhat with seepage from their reservoir for a few rods around it and are going to try the experiment of sowing alfalfa on the land affected and thus perhaps reclaim it. Two men give personal attention to the garden, giving it their entire time, and employing additional help according to the season and its attendant work.

The Risdon well, famous as being one of the largest and strongest in the basin, is located on section 32, township 111 north, range 61 west, about 2 miles northeast of Huron. Though not used, having been in litigation for years, it is worthy of mention because of its great possibilities. It is an 8-inch well finished with 6-inch casing below, is 935 feet deep, and originally flowed 2,250 gallons per minute. The well was used for power purposes at one time, generating electricity for the city of Huron. At that time it was shut off during the day and opened at night. This resulted in its clogging and losing part of its flow, and it was abandoned for that purpose. It stands now partly closed, flowing off into pastures, where it forms pools where the cattle may drink. This well is admirably located for irrigation purposes. The greater part of a half section on the uplands is capable of being brought under ditch directly from the well, while the lowlands of the James River Valley lie about 100 rods to the east, where all the water could be utilized. A fine natural reservoir site is formed by a large ravine about 60 rods from the well, where an embankment, with a length of perhaps 20 rods, could be made to retain water to a depth of 20 feet. This ravine is accessible for a reservoir back for nearly half a mile, where an embankment is already formed across it by the roadbed of the Great Northern Railway. This reservoir site overlooks the James River Valley land, and the water could be carried down along the bluffs for any distance to the land below, so that the entire winter's flow could be stored and utilized. There is opportunity for a great irrigation enterprise here, one of the best in the whole James River Basin.

Mr. C. M. Bell has a farm half a mile north of Huron equipped for irrigation, having a 3-inch well 760 feet deep, flowing 120 gallons per minute. He has a storage canal 36 rods long and 20 feet wide, which can be filled about 4 feet deep. The water has not been used this year except for a few trees. A large garden was successfully operated in 1902, though no specific data could be obtained. Nearly the entire quarter section can be brought under ditch from this well, as well as many acres on adjoining farms.

R. D. Wharton, in the south part of the city of Huron, operates a market garden of 15 acres, irrigated by means of pipe attached to the city hydrant. He has a system of pipes lying on the ground with valves every 50 feet, to which he can attach hose. He lays his pipe line along a ridge on the upper edge of a field, connects with the hydrant by means of a short hose, and carries the water without loss direct to that part he wishes to irrigate. Mr. Wharton emphasizes the fact, also brought out by Joy Brothers, that the aim should be to supplement the natural rainfall when necessary, but one must be careful about making the land too wet. Often he does not have to irrigate certain portions of his garden at all during the season, the natural rainfall and subsoil waters left from the previous year's irrigation being sufficient. The garden has yielded 250 bushels of onions per acre, 1,000 bushels of carrots per acre, 7,000 to 9,000 head of cabbages per acre, $600 worth of celery per acre, and $125 worth of muskmelons from five-sixteenths acre. All other garden crops yield in equal abundance. He estimates an average income of $150 per acre from his garden.

One of the most extensive systems of irrigation in Beadle County was started about 8 miles north of Huron on section 30, township 112 north, range 61 west, by the Consolidated Land and Irrigation Company of Huron. It had a 6-inch well 916 feet deep, flowing about 500 gallons per minute, and a reservoir of about 7 acres, which could be filled to a depth of 6 feet or more. Several miles of ditch, and a storage canal on the next section east were constructed, and the farm systematically worked for a few seasons (1891–92). Good results were obtained, the crops being more than double those of the unirrigated lands in that locality. The farm, however, established for speculative purposes, has changed hands several times and was without a tenant some years. At present it is lying idle, only needing intelligent management to make it one of the best paying farms in the vicinity. Seepage has spoiled some of the land contiguous to the reservoir, but by proper management the ground can easily be reclaimed.

E. D. Fuller, living 4 miles south of Cavour, on section 23, township 110 north, range 60, is one of the latest to begin irrigation in this county. He has a 2-inch well 772 feet deep, flowing 82 gallons per minute, dug in June this year (1903). His well is located with reference to use for irrigation, and he carried water this season into a 15-acre field of corn, though not in as systematic a manner as he wished. A measurement of stalks which received water compared with some in the same field to which water was not carried showed the former to be 2½ feet taller and much more thrifty looking. His garden was watered also and has proved much more fruitful than it otherwise would have been. Mr. Fuller irrigates direct from the well. He has about 75 acres he can put under the ditch.

There have been several other irrigation plants in Beadle County which have been abandoned because of change of owners or the clogging of the wells. Many of the smaller 1¼-inch and 2-inch wells have been sunk recently for stock watering, though several are also planned to be used for irrigation if necessary.

DAVISON COUNTY.

The Hatch Brothers, on section 15, township 103 north, range 62 west, adjoining the village of Mount Vernon, have two 2-inch wells about 400 feet deep, which flow about 60 gallons per minute. Each well is equipped with a reservoir, and over 100 acres can be brought under the water. These wells were dug about 1897 and during the next two years they were used to irrigate trees, potatoes, and garden. Since then they have not been used, as the rainfall has been greater and seemed adequate.

John K. Johnson and his brother, Joseph K. Johnson, living on sections 3 and 4, township 103 north, range 62 west, also have wells with reservoirs, though they have not used them for irrigation for two years. Joseph irrigates only a small orchard and home garden. John Johnson has experimented quite largely in small grain and gives a very satisfactory report of his success. He has raised, per acre, 27 bushels of wheat, when unirrigated wheat yielded 10 bushels; 60 bushels of oats, when unirrigated oats yielded 30 bushels, and 60 bushels of corn, when unirrigated corn yielded nothing. Mr. Johnson has two wells, one 4½-inch, 650 feet deep, flowing 375 gallons per minute, and one 2-inch well, 411 feet deep, flowing 10 gallons per minute. He has a reservoir of about 7 acres, which is very shallow, and the excessive seepage from it has spoiled some land near it. He can run water upon a whole section and has over 2 miles of main ditch.

Ira Frazier, on section 27, township 104 north, range 61 west, about 12 miles northeast of Mitchell, has a 4-inch well and small reservoir. He also irrigates small grain by flooding his land in the fall and winter, though he does no systematic work. Though his crops are reported as better where the water has been allowed to run than where not, he can give no specific report of advantages. Mr. Frazier made the mistake one season of letting the water flood his land all winter, piling up ice in some places. The result was that in the spring he could not get on his ground until very late, and the soil was so wet and cold his grain did not germinate readily, and his crop was poorer than without the water. The next year, however, this land yielded well.

Nick Reimers, on section 21, township 103 north, range 61 west, 6 miles west of Mitchell, has a 2-inch well, 300 feet deep, flowing about 15 gallons per minute. From this small well he irrigates 8 acres of market garden. He can carry the water to 20 acres, but can not attend to it all. Mr. Reimers raises large quantities of vegetables of all kinds for the local market in the city of Mitchell. He has no reservoir, but runs ditches direct from the well to the land. He reports his land as bringing him $100 or more per acre.

JERAULD COUNTY.

The greater part of Jerauld County is so high that wells can not be obtained, but the eastern part, occupied by the valley of Firesteel Creek, is located very favorably for irrigation, and a well can be secured almost anywhere. Though the rainfall seems to be less than farther east, little is done in irrigation, as stock raising forms the chief occupation of the people.

Charles Walters, 9 miles southeast of Wessington Springs, on section 15, township 106 north, range 64 west, has a 3-inch well, 816 feet deep, which flows 300 gallons per minute. He irrigates from 150 to 200 acres of small grain and corn. His plan is to plant about 40 acres of corn and irrigate it well. The next year he sows this to small grain without irrigation and plants another 40 acres to corn and irrigates it. He carries the water direct from the well, his land lying so favorably that a plow furrow will usually carry water where it is wanted. He usually irrigates his small-grain fields in the fall after plowing, giving them a good soaking so as to be ready for spring sowing. He is careful, however, to let no water stand and freeze on his land, and so render it cold and soggy for spring work. Mr. Walters notes three points of advantage in irrigation, namely: His crop is nearly doubled, his crop is sure, and his grain is first grade. He states that since he has used his well he has had nothing but No. 1 wheat, while his oats and other grain always overrun regulation weight. Mr. Walters has no trouble in carrying water the entire length of his field, about three-fourths mile. He has a fine grove which he started with irrigation, but uses no water in it at present.

Peter Schultz, 7 miles southeast of Wessington Springs, on section 9, township 106 north, range 64 west, has a 2½-inch well, 880 feet deep, which flows 280 gallons per minute. He irrigates a garden and orchard, though at present he uses no water in the latter, since it lies just below his garden and receives sufficient moisture by seepage from the garden. His orchard looks very thrifty. Fifty trees bore fruit of excellent quality in 1903.

Henry Allen, working the northeast quarter of section 6, township 106 north, range 63, has a 3-inch well, 782 feet deep. He irrigates small grain only, by flooding in the previous fall. He estimates that his crop is double what his neighbors get without irrigation.

William Kline, 3 miles north of Wessington Springs, on section 25, township 108 north, range 65 west, has a 3-inch well, 963 feet deep, flowing 400 gallons per minute. Thus far Mr. Kline has irrigated only a home garden, but this year he has built a large pond of 15 acres from which he intends to irrigate about 135 acres, putting part of it into alfalfa.

There was formerly another irrigated farm, 10 miles north of Wessington Springs, worked by Charles Le Bau, but the well failed and nothing has been done lately. Another well has been dug this year, and operations will probably be resumed.

KINGSBURY COUNTY.

Only the western eight tiers of sections in Kingsbury County lie in the artesian basin. A number of wells are found in the region, but few of them are used for irrigation.

K. Fingerson, 2 miles west of Esmond, has a 2-inch well, 850 feet deep, flowing 80 gallons per minute. His well was just dug in 1902, but he has irrigated about 35 acres of oats this season (1903) by flooding. His crop, though hurt by a late frost, is still much better than that on his fields that have had no water. He also irrigated a potato field, and reports a fine yield from it. Mr. Fingerson intends to extend his system further next year and bring about 70 acres under ditch, using the water alternately on different portions during different years.

C. L. Spear and E. Gulbronson, 3 miles south of Manchester, each have sunk wells recently and intend to irrigate.

SPINK COUNTY.

The best and most systematic irrigation plant in the whole artesian basin is that of A. J. Glidden, at Hitchcock, on section 33, township 114 north, range 63 west. Mr. Glidden's well is 4½ inches in diameter, 1,150 feet deep, and has a flow of 450 gallons per minute. The well was dug in the winter of 1894–95, and irrigation was commenced the next season. He irrigates from 60 to 80 acres, though he has water enough for 200 acres if he could take care of it. Mr. Glidden supplements his well with a reservoir of about 20 acres, which he can fill 5½ feet deep, and has his land arranged so he can use water direct from the well on part and from the reservoir on the remainder. He has 2 miles of shelter belts, consisting of a double row of forest trees, running through his fields at intervals of about 60 rods. These break the winds and protect his fields from early fall and late spring frosts, which are prevalent in this section. His explanation of this fact is that the moisture rising from the fields, if not blown away by the winds, forms a blanket over the garden, which protects it from the frosts. The shelter belts, breaking the wind, prevent this blanket from blowing away and leaving the field unprotected. Mr. Glidden took $8,000 worth of produce off his farm during the years 1901 and 1902. The year 1903 has been very favorable and will probably give as good results. He gives the most complete statement of yields for the year 1902 of any person interviewed. Eighteen acres of cabbage yielded 95 tons; 3 acres of onions yielded 1,000 bushels; 2 acres of tomatoes yielded 150 bushels ripe and 500 bushels green; 6 acres of potatoes yielded 500 bushels; 2 acres of popcorn yielded 80 bushels; ½ acre of parsnips yielded 200 bushels; ½ acre of carrots yielded 250 bushels; ¼ acre of beets yielded 200 bushels; 2 acres of squash yielded 5 tons (planted with corn); 1 acre of pumpkins yielded 4 tons (planted with corn); 1 acre of smaller truck yielded 900 bushels, at 50 cents per bushel; 10 acres of field corn yielded 300 bushels of sound corn; 25 acres of oats yielded 1,300 bushels; 5 acres of spelt yielded 200 bushels; 10 square rods of strawberries yielded 14 bushels; 200 currant bushes yielded 10 bushels, and 100 gooseberry bushes gave a big yield. Apple, plum, crab apple, and cherry trees are all doing well, many are already bearing, and others developing each year promise finely. Mr. Glidden's farm is an excellent example of what can be done by irrigation intelligently practiced here in the artesian basin.

T. S. Everett and S. S. Budlong each have farms east of Hitchcock, arranged for irrigation, but nothing is being done at present by either of them, as the season was considered favorable for small grain without irrigation. They each report that in ordinary years they have doubled their crop by watering it, that they are always sure of a crop, and that it will be first grade when water is used. The farms are now in the hands of tenants, who know nothing of irrigation and do not care to bother with it. Mr. Everett reports 30 bushels of wheat, 75 bushels of oats, and 40 bushels of corn per acre from his land.

J. M. Miles, of Redfield, irrigates about 15 acres with water from the city hydrant. It is entirely in garden and orchard, and he can irrigate but a small portion each year, as he has but little water. He intends to sink a well on his land and work more systematically soon. He reports large yields of garden vegetables, but nothing in detail except celery, which yields him about 1,000 dozen bunches per acre, which, at 50 cents per dozen, brings him $500.

The H. F. Hunter farm, section 4, township 119 north, range 64 west, and adjoining sections, is equipped with a 6-inch well, 1,065 feet deep, flowing 1,250 gallons per minute. It has a 5-acre reservoir and about 5½ miles of main ditch. The water is not used for 1903, as the season has been so favorable that the moisture remaining in the ground from previous irrigation has proved sufficient for the crops. During the years when this farm was irrigated the yields of small grain were just about double that of unirrigated grain in that locality, while potatoes and garden crops generally were increased threefold or more. It requires the entire time of one man to keep ditches in repair, clean off the grass, and direct the water when irrigating. Two other wells in this vicinity were previously used for irrigation, but they ceased to flow some time ago.

Among the counties in which irrigation has been attempted are

Brown, Charles Mix, and Sanborn, but practically nothing has been done in these for several years. The seasons have been reported as very favorable without additional moisture.

COST OF WELLS.

The cost of digging these artesian wells varies with the size and depth. They are constructed much cheaper at present than at the time the larger wells were dug. In 1891–1895 a 6-inch well cost from $2,000 to $3,500. Nearly all the wells dug at present are the smaller sizes—1½, 2, or 3 inches in diameter—and their cost ranges from $400 to $1,000, according to size and depth, the regulation charge being for a 2-inch well (the greater number being that size) about 60 cents per foot.

DUTY OF ARTESIAN WATER.

The most successful irrigators in the artesian basin emphasize the fact that here the need is not to supply all the moisture required for a growing crop, but simply to supplement the rainfall.

The main defect in the rainfall is that it does not always come at the time it is needed. To remedy this condition and to guard against the danger of too much moisture when the rains do come are the problems before the farmer in this section. Experience has proved that it is a very easy matter to get too much water, and that its effect is more disastrous than too little. Owing to the fact that the precipitation is very nearly sufficient to mature the ordinary small-grain crops, the amount of water which would be required for a 40-acre tract in the arid regions would be sufficient for twice or even three times that acreage here. Under proper conditions, with a reservoir for storage purposes, those who have estimated most closely say that a 2-inch well will supply all the water needed on a half section of land, while a 4-inch well would supply a section. This does not mean that the entire half section could be covered each irrigating season, but it has been found that a tract having a thorough irrigation during one season will raise a full crop of small grain the next season with no extra water, for the water already in the soil is sufficient to fully supplement the rainfall.

This method has proved more successful than continued irrigation, as it guards against saturation and its attendant soil deterioration due to the deposit of salts.

METHOD OF IRRIGATING.

The method employed in irrigating varies somewhat with the crop. For small grain the general plan is to plow the field in the fall and then irrigate by flooding, letting the water run until the ground is well moistened, but not long enough to allow water to stand on the field. This leaves the ground so that it can be worked in season and furnishes moisture to germinate the seed. In ordinary years this is sufficient, but in a dry season another watering is given just as the grain is beginning to head. If water is applied much earlier than this the ground, not being sufficiently shaded by the foliage, is apt to bake and form a hard crust over the surface. On the other hand, if watered later it retards the maturing of the grain and impairs its quality.

Several farmers tried the plan of allowing the water to flood their land all winter, letting it flow unrestricted over the fields. This proved detrimental and even disastrous in some cases. The ground became so wet that it could not be worked till late and the soil remained so cold that seed rotted before it could germinate, and the result was a swampy weed patch instead of a field of grain. It is hard for beginners to rid themselves of the idea that if a little water is a good thing more is better; and more irrigators in this section have failed in their efforts and given up entirely from the effects of overirrigation than from any other cause.

Those who have been most successful financially are the market gardeners. Their methods vary with the different crops and seasons. Their aim is to have the ground well moistened at seed time to insure quick germination. After that they simply watch the crop and water when needed. These crops are almost invariably watered by the furrow system, letting the water flow down between the rows of vegetables and seep to the roots. Cultivation within three or four days after irrigation is essential to prevent the ground from baking. The early vegetable crops, as garden peas, beans, radishes, lettuce, etc., are usually grown as quickly as possible and disposed of, the ground being cleared off for another crop of millet or turnips, or utilized to set out late cabbage and tomato plants. In this way two crops are raised on the same land, the irrigation for the first crop being sufficient for maturing the following one.

Fruiting crops, such as strawberries and tomato vines, are watered just as the fruit is beginning to set, unless the rainfall has left the soil in proper condition. Meadows are irrigated by flooding in the spring and after each crop, except the last. This has been found especially favorable for tame grass and alfalfa.

OBJECTIONS TO ARTESIAN IRRIGATION.

Aside from the danger of a rain coming immediately after irrigation making the soil too wet, the chief objection to irrigation by artesian waters is due to a belief that various salts contained in the water poison the soil and render it unfruitful. Special inquiry was made regarding this matter, and those who have used the water in irrigation the most extensively were unanimous in the statement that there were no injurious effects if the water were properly used. The experiences of Joy Brothers and Mr. Glidden agree on this point. They find that water is frequently applied in such excessive amounts that the rootlets are smothered and the soil is covered by standing water which on evaporation leaves a deposit of salts. Hence many conclude that the salts have killed the vegetation, whereas it is the superabundance of water instead. In nine years' experience with proper handling of the water they have found no difficulty nor any indication that there will be any in the future. A complete analysis of the artesian waters from wells in different parts of the artesian basin was made by Prof. J. H. Shepard, of the South Dakota Agricultural Experiment Station, to determine the quantity and nature of the salts and their effects on the soil and vegetation.[a] His conclusions are as follows:

> It is undoubtedly true that the artesian waters of the Dakota Basin do carry large quantities of soluble constituents. The residues from these waters are larger than those of most waters used for irrigation; but when the various climatic conditions of the basin are taken into consideration, and when the drainage and soil conditions of the most favorable kind are considered, it is not unwarrantable to suppose that favorable results may be obtained by an economical and judicious application of the artesian waters. Especially is this true when one remembers that during many years no irrigation at all is desirable. And then again, all parts of the basin are subject to such heavy falls of rain that any accumulating salts must of necessity be washed away. Then again, even in the driest years, the period when crops would be benefited by irrigation is short, so that only a limited application of water would be needed. All these facts would lead one to believe that such irrigation as needed here may be accomplished by artesian waters.

A tabulated statement of Professor Shepard's analyses is given below:

Analyses of the waters from ten typical wells in the artesian basin.

BASES AND ACIDS (parts per 1,000).

Location of well.	Soda, Na_2O.	Lime, CaO.	Magnesia, MgO.	Carbon dioxid, CO_2.	Sulphur trioxid, SO_3.	Chlorin, Cl.
Yankton	0.1384	0.4304	0.1054	0.0548	0.7860	0.0996
Armour	.2046	.5214	.1671	.0684	1.0214	.1745
Woonsocket	.4070	.3120	.1234	.0717	1.0090	.0684
Huron	.3743	.3349	.1421	.0684	.9806	.1240
Iroquois	.9860	.0109	.0168	.1280	.9095	.1575
Hitchcock	.3520	.3737	.1462	.0675	1.0479	.0967
Redfield	.8546	.0478	.0316	.0931	.8841	.1592
Northville	.4102	.4064	.1330	.2455	.4911	.3877
Aberdeen	.8552	.0492	.0386	.0857	.9312	.1443
Westport	1.3004	.0112	.0184	.2561	.2352	.9110

PRINCIPAL SALTS (parts per 1,000).

Location of well.	Sodium chlorid, $NaCl$.	Sodium sulphate, Na_2SO_4.	Sodium carbonate, Na_2CO_3.	Magnesium sulphate, $MgSO_4$.	Magnesium carbonate, $MgCO_3$.	Calcium sulphate, $CaSO_4$.	Calcium carbonate, $CaCO_3$.
Yankton	0.1643	0.1172	----------	0.3160	----------	0.8700	0.1246
Armour	.2879	.1186	----------	.5011	----------	1.0550	.1554
Woonsocket	.1128	.7941	----------	.3701	----------	.5360	.1630
Huron	.2046	.6083	----------	.4261	----------	.6020	.1554
Iroquois	.2598	1.6153	0.2432	----------	0.0353	----------	.0195
Hitchcock	.1595	.6120	----------	.4384	----------	.6989	.1534
Redfield	.2626	1.5701	.0499	----------	.0664	----------	.0854
Northville	.6396	.1620	----------	.3988	----------	.2280	.5580
Aberdeen	.2381	1.6538	.0108	----------	.0811	----------	.0879
Westport	1.5031	.4177	.5475	----------	.0386	----------	.0200

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[a] South Dakota Sta. Bul. 81.

Analyses of the waters from ten typical wells in the artesian basin—Continued.

SOLUBLE AND INSOLUBLE SALTS (parts per 1,000).

Location of well.	Total salts.	Soluble after evaporation.	Insoluble after evaporation.
Yankton	1.6023	0.5975	1.0048
Armour	2.1392	.9076	1.2316
Woonsocket	2.0088	1.2770	.7318
Huron	2.0334	1.2390	.7944
Iroquois	2.1831	2.1183	.0648
Hitchcock	2.0868	1.2099	.8769
Redfield	2.0546	1.8826	.1720
Northville	2.0380	1.2004	.8376
Aberdeen	2.0909	1.9027	.1882
Westport	2.5501	2.4683	.0818

The results attained upon the experiment station plats at the Hunter farm near Mellette corroborate Professor Shepard's conclusions:

> Some have professed a belief that a continued application of artesian water would result in overloading the soil with soluble salts, detrimental alike to the tilth of the land and to the growth of vegetation. Under the climatic, soil, and drainage conditions prevalent this belief has little foundation, especially if care be used in the application.[a]
>
> If anything is needed in the artesian water it is animal and vegetable organisms. This, however, may be obtained by storing water in a reservoir.[b]

RAINFALL.

Many think that the great number of ponds created by artesian wells will have a tendency to increase the moisture in the air by evaporation and that it will result in more rain and greater frequency of showers, thus giving a better distribution of moisture throughout the growing season, and that this alone will obviate the necessity of irrigation. While occasional light local showers have apparently been produced from the vapor arising from some of these ponds, yet the greater part of the moisture is carried by the winds a long distance, and is precipitated where it does no good to the farmers of this valley. On account of the great fluctuation of the amount of moisture for the last few years it is difficult to determine whether there has been any actual increase due to this cause. At best, though, this would add very little to the rainfall, and the total amount would still be inadequate during periods of ordinary or extra-dry weather.

The fact that the present period of favorable rainfall has been coincident with the filling up of these ponds is undoubtedly the basis of the opinion that the existence of the ponds increases rainfall. The rainfall for the last eight years has been very favorable, both in amount and distribution, as is shown by the following table given for Huron, which is centrally situated and representative of the conditions throughout the valley:

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[a] South Dakota Sta. Bul. 52.

[b] South Dakota Sta. Bul. 28.

Precipitation at Huron, S. Dak., from 1896 to 1903.

Month.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	0.45	2.87	0.01	0.26	0.07	0.13	0.32	0.08
February	.46	.52	.22	.33	.14	.28	.39	.31
March	1.71	1.53	.84	1.13	1.40	.79	1.56	1.02
April	6.17	4.03	2.89	1.04	2.16	.86	1.11	1.26
May	2.95	.46	2.90	2.96	.62	1.78	2.24	1.99
June	5.18	3.81	1.81	2.91	4.00	6.46	3.55	2.54
July	1.62	2.32	3.83	.90	5.59	.64	1.53	1.61
August	1.17	2.69	.46	2.06	6.66	2.50	2.36	1.09
September	2.36	1.14	1.31	.29	2.39	6.75	.19	2.62
October	1.70	2.13	1.01	1.43	1.47	1.11	.76	.34
November	1.97	.67	.23	.16	.17	.08	.29	.37
December	.36	.57	.11	.19	.06	.60	2.12	.60
Total	26.10	22.74	15.62	13.66	24.73	21.98	16.42	13.83

While reports from all parts of the valley mention the abundant rainfall, during the more recent years a study of the precipitation records shows that there has been little change in the total precipitation, the very favorable conditions being due more to better distribution than to a greater amount.

CONCLUSIONS.

As a result of this series of investigations the following conclusions are established:

(1) Irrigation can be practiced to advantage during most of the years, though there is occasionally a year when the moisture is sufficient and properly distributed.

(2) The wells are not called upon to furnish all the water needed for crops, but merely to supplement rainfall.

(3) Care must be taken that the soil does not become too wet.

(4) The salts in the waters and those drawn from the land have not thus far had any detrimental effect, nor do they give indications that they will have in the future. All cases of deterioration of the soil are directly traceable to an oversupply of water.

(5) Under irrigation the farmer is practically sure of a crop each year.

(6) In ordinary or extra dry years the crop is increased two and sometimes three fold.

(7) The crops are always of superior quality, grading No. 1 when unirrigated crops grade No. 3 or are even rejected.

(8) A good 2-inch well supplemented by a reservoir will furnish water for a half section of land.

(9) The main drawbacks are the lack of knowledge regarding the practical handling of water in the field and the too lavish application, especially if soon followed by rain.

(10) During the last seven or eight years very little advancement has been made in irrigation farming, but at present farmers are arranging their wells with reference to a probable future use, and when the necessity again arises many will be prepared and will make use of their supply.

In general, those who have not waited for the necessity to arise, but have practiced irrigation as a part of improved and intensified farming, have found it profitable even under the present favorable natural conditions.

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